

## Alum Retannage for More Serviceable Leather Insoles\*

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In studies made by this Laboratory<sup>1,2</sup>, it has been found that vegetable tanned leathers retanned with alum have high resistance to acid deterioration. The effects of alum retannage are quite analogous to those of chrome retannage. Bookbinding and upholstery types of leather were used in this work. A commercial tanner has produced with no difficulty leather of this type which was of good quality, gave good performance in bookbinding operations and had high resistance to acid deterioration.

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Further tests<sup>3</sup> were made on alum retanned leathers to determine other properties in addition to their resistance to acid deterioration. It was found that the alum retannage of vegetable leathers has practically no effect on the stretch of the leathers or on their strength, whether measured as tensile strength or resistance to tearing, bursting or folding. It improves the ventilating properties because it increases the porosity to air and resistance to wetting and water absorption, while it leaves the permeability to water vapor unchanged. The most striking change due to retannage is the increased resistance to moist heat. The shrinkage temperatures of the retanned leathers ranged from 105° to 113° C., whereas those of the straight vegetable tanned leathers were, in general, below 70° C. The alum retanned leathers may be boiled for 3 minutes without shrinkage or other damage. We have also found that the retannage imparts a high resistance to mold growth.

These properties of alum retanned leather suggested its use for types of leather other than bookbinding or upholstery. One of these suggested uses was for insole leather. During the war one of the major problems of the Quartermaster Division of the Army was the production of durable and comfortable insoles for Army shoes. In 1944 the Quartermaster Division made a test at Camp Lee of 12 types of insole leather tanned and treated in various ways. Included in this test were insoles made of commercial vegetable tanned belly stock leather retanned with alum in this Laboratory. Pairs of insoles each consisting of one treated and one untreated leather were subjected to wearing tests, and the durability of the treated and untreated leathers was compared. Each test was divided into two parts, one of normal wear and the other of wear on a specially constructed track. After these tests, the insoles were examined in the following manner.

"Analysis of the insoles was made by segregating the failures into the following major types: cracking, guttering, curling, buckling, wrinkling, and shrinking. The extent of each type of failure was rated from 0 to 100 points, assigning numerical values to six specific degrees of deterioration (0-20-40-60-80-100). The effect of the various treatments on the insoles was then determined by direct comparison of the treated and untreated insoles of the same pair of boots, and the relative effectiveness of each treatment was determined by comparing the differences in the average extent of deterioration for all failures between the treated and untreated insoles of each treatment"<sup>4</sup>. On the basis of a comparison of the treated soles with the untreated controls, the alum retannage resulted in a decrease of 55.2 per cent in the number of failures for track wear and 68.8 per cent for normal wear<sup>5</sup>. The only leathers with a higher percentage of decrease in the number of failures were two types of chrome retanned vegetable leathers.

For the alum retannage of these leathers, we had used the procedure used with bookbinding leathers, except for increased time. With the thinner bookbinding leather this procedure had given more than a 3 per cent  $\text{Al}_2\text{O}_3$  content,

but with these thick leathers only 1.8 per cent was obtained. Our previous tests<sup>1</sup> have shown that more than 3 per cent  $\text{Al}_2\text{O}_3$  is required for the maximum benefits of retannage. Furthermore, the shrinkage temperatures of these leathers as measured by the Provisional method of the American Leather Chemists Association<sup>6</sup>, was 90-92° C., instead of more than 100° C. as in previous tests. Although it is not necessarily true that the quality of leather in general may be determined by the shrinkage temperature, in comparing leathers of this type the shrinkage temperature determination is of great value. The low shrinkage temperature was confirmatory evidence that the retannage was insufficient.

Our work was directed to obtaining a more thorough retannage. This involved obtaining not only a higher percentage of  $\text{Al}_2\text{O}_3$  (more than 3 per cent), but also a more uniform distribution throughout the thickness of the leather. Even with a high  $\text{Al}_2\text{O}_3$  content, if the distribution is so poor that only small amounts of  $\text{Al}_2\text{O}_3$  are in the middle layer, that layer on boiling will become black and amorphous and will shrink, thus causing a distortion of the entire thickness of the leather. Increased time and concentration were of some value in increasing the total  $\text{Al}_2\text{O}_3$  concentration, but resulted in poor distribution.

Of much more promise were "masking" agents. Several workers have described the use of these materials in chrome liquors. Theis and Kleppinger<sup>7</sup> have summarized some of these investigations and have given their results with sodium formate. The use of these masking agents in chrome or alum liquors allows the basicity and the pH to be raised above the normal precipitating point without causing a precipitate. If comparatively small amounts of these agents are added and the basicity is increased in general, the tanning powers of the liquors will increase. If sufficient masking material is added, however, no precipitate will be formed, no matter how much alkali is added, but such liquors usually have no tanning power. It follows, therefore, that for every masking agent there is an optimum concentration. The masking effect varies with the material used. Also the various materials have different effects on chrome and alum liquors, and therefore the optimum concentrations are not identical. Further, the effects of the masking agents on vegetable tanned leathers and on raw pelts are different, and since the penetration of the liquors is involved, the thickness of the leather used is a factor.

Considering all these variables, it is evident that determination of the optimum concentration of the most satisfactory masking agent would be a time-consuming task. This was not attempted. Some of the most satisfactory materials, both as to results and cost, were tried at concentrations recommended in the literature. Some of these were the sodium salts of the following acids: acetic, lactic, formic, citric, tartaric, and phosphoric, with mixtures of some of them. They were used in the proportion of one mole of the masking agent to one mole of aluminum sulfate. Sodium citrate was the most efficient

and of reasonable cost. On several tests of small pieces we obtained a uniform  $\text{Al}_2\text{O}_3$  content of more than 3 per cent and a shrinkage temperature of more than  $100^\circ \text{C}$ .

Having apparently solved the problem of obtaining the desired  $\text{Al}_2\text{O}_3$  content, our next step was the tanning of leather on a larger scale. Two hides were obtained from a commercial tannery. One had been limed and unhaired and was ready for tannage. This was cut into blocks and tanned in the laboratory with liquors made from a blend of quebracho and chestnut extracts. Variations were made in the time of tanning so that the effect of the degree of vegetable tannage on the subsequent retannage might be determined. Treatment of hides before tannage with a commercial brand of sodium hexametaphosphate to increase the rate of vegetable tannage has been recommended and is used to some extent commercially. Some blocks were pretanned with this material to determine its effects on vegetable tannage and subsequent alum retannage. After vegetable tannage, one half the blocks were alum retanned with alum liquors masked with citrate. The remaining blocks, each paired with an alum retanned block from the opposite side of the animal, were saved for controls. Comparative physical tests were made as described later.

The other hide obtained was vegetable tanned at the tannery in their usual tanning liquors to the point where it was fully "struck through." One side of this was dried, oiled and finished for the control. The other side was cut into blocks and retanned with alum liquors of two concentrations, 4 and 8 per cent  $\text{Al}_2\text{O}_3$ , and for two periods of time, 3 and 5 days. Half the liquors were masked with citrate, and the rest were unmasked. Comparative physical tests were made on the finished leathers.

The shrinkage temperatures, the water absorption capacity, the tensile strength, and the elongation of the leathers were determined by the methods of the American Leather Chemists Association<sup>6</sup>, except that the dumbbell-shaped test strip used for tensile strength was 1 cm. wide and 2.5 cms. long between shoulders. Porosity to air and permeability to water vapor were determined by the methods of Wilson and Merrill<sup>8</sup>. These are not included in the tables because there were no significant differences between control and alum tanned pieces.

Table I gives the data on the retanned leather that was vegetable tanned in the laboratory. These results show that under the same conditions bellies and shoulders fixed more  $\text{Al}_2\text{O}_3$  than did bends. As the degree of vegetable tannage was increased by longer time in the liquors, there was a tendency for a lower pick-up of  $\text{Al}_2\text{O}_3$  in the subsequent retannage.

The shrinkage temperature increased with increasing  $\text{Al}_2\text{O}_3$  content of the leather. Retannage caused a decrease in water absorption and elongation, the effects of each being more pronounced in the belly and shoulder than in the bend. The average tensile strength of the alum retanned leathers was

TABLE I  
Laboratory-Tanned Leathers Retanned with Citrate-Masked Alum Liquors

Tannage	Time of Vegetable Tannage	Days	Al <sub>2</sub> O <sub>3</sub> Content	Shrinkage Temperature	Gain in Weight	Loss in Area	Water Absorbed in 2 hours	Tensile Strength	Elongation*
			Per Cent	°C.	Per Cent	Per Cent	mg./sq. cm.	lbs./sq. in.	Per Cent
<i>Bends</i>									
Vegetable control.....	31	31	—	76	—	4.7	157	3380	24
Regular vegetable tannage + alum .....	17	17	2.1	96	9.9	4.1	113	3310	23
Regular vegetable tannage + alum .....	24	24	1.9	94	9.3	2.2	104	2910	15
Regular vegetable tannage + alum .....	31	31	2.0	93	12.1	3.4	112	3830	28
Regular vegetable tannage + alum .....	12	12	2.7	98	7.4	2.7	118	3720	28
Hexametaphosphate pretannage + alum ..	19	19	2.2	94	9.4	2.1	112	3070	21
Hexametaphosphate pretannage + alum ..	26	26	2.2	95	8.9	2.9	113	3780	21
<i>Bellies and Shoulders</i>									
Vegetable control.....	31	31	—	76	—	6.9	173	2540	54
Regular vegetable tannage + alum .....	17	17	2.3	95	13.3	4.6	105	2740	24
Regular vegetable tannage + alum .....	24	24	2.3	95	13.4	4.7	104	2510	25
Regular vegetable tannage + alum .....	31	31	2.2	94	9.4	2.1	117	3070	21
Regular vegetable tannage + alum .....	12	12	3.1	106	12.6	4.5	118	2850	28
Hexametaphosphate pretannage + alum ..	19	19	2.9	101	13.0	5.6	109	2900	26
Hexametaphosphate pretannage + alum ..	26	26	2.7	98	10.6	7.4	103	3590	32

\* At load of 50 kgs. per cm.

greater than that of the control. These results were so variable, however, that they were probably not significant. On retannage, there was a slight gain in weight and loss in area. It will be noted, however, that the loss in area was no greater in the retanned leathers than in the controls, which were subjected to the same operations as the retanned pieces except for the alum retannage. The degree of vegetable tannage ranged from 49 to 54, according to the time of tannage. This was raised by retannage by an amount proportional to the  $\text{Al}_2\text{O}_3$  content, becoming 63 in the leather with the most  $\text{Al}_2\text{O}_3$ . It will be noted that most of the leathers shown in this table contained less than the desired 3 per cent  $\text{Al}_2\text{O}_3$ .

The results of the retannage of the commercial vegetable tanned leather are shown in Table II. In addition to confirming some of the results shown in Table I, these show that the amount of fixed  $\text{Al}_2\text{O}_3$  increased with the concentration of aluminum in the tanning liquor and with the duration of tannage. The degree of tannage at the start was 50 per cent for the bend and 62 per cent for the belly and shoulder. The retannage increased this in proportion to the  $\text{Al}_2\text{O}_3$  fixed, being 64 per cent for the bend piece and 74 per cent for the belly piece of the highest  $\text{Al}_2\text{O}_3$  content. In these leathers also, the amount of  $\text{Al}_2\text{O}_3$  fixed was less than desired. Further, a direct comparison between the masked and unmasked liquors indicates that as used in this test masking had no advantage.

An investigation was next made to determine the reason for the discrepancy between these results and those obtained in our preliminary tests. It was found that on standing for a few days stock alum liquors masked with sodium citrate became increasingly viscous, finally turning into a gel. Since our preliminary tests were made with freshly prepared liquors, this effect was not noticed, but for the larger test, liquors were prepared several days ahead, and their viscosity prevented proper penetration. In further tests with masking materials, sodium acetate gave satisfactory results, and the stock liquor did not become viscous on standing.

Experiments were conducted to determine the optimum pH for  $\text{Al}_2\text{O}_3$  fixation. With sodium acetate in the liquors as a masking agent, a pH as high as 5 may be obtained without precipitation by the addition of sodium carbonate. However, the penetrating power of such a liquor is poor. It was found advisable to start the tanning at a lower pH, about 3.8, to insure penetration into the interior of the leather. In the later stages of tanning, the pH was raised to 4.8 - 5.0 by the addition of sodium bicarbonate or borax in small portions over an interval of 1 or 2 days. This insures the proper fixation of  $\text{Al}_2\text{O}_3$ .

Two hides were tanned in a manner similar to that used in the first test, with alum liquor masked with sodium acetate. For this test our laboratory tanning drum was used. This is similar to the usual commercial tanning drum except for its smaller size. The time of tannage was 1 week, the drum being

TABLE II  
Commercially Tanned Leathers Retanned with Masked and Unmasked Alum Liquors

Tannage	Time of Retannage	Al <sub>2</sub> O <sub>3</sub> Content	Shrinkage Temp.	Gain in Weight	Loss in Area	Water Absorbed in 2 Hours	Tensile Strength	Elongation*
	Days	Per Cent	°C.	Per Cent	Per Cent	mg./sq. cm.	lbs./sq. in.	Per Cent
<i>Unmasked liquors</i>								
Bends								
Vegetable control.....	—	—	76	—	3.5	139	2540	20
Retanned with 4% Al <sub>2</sub> O <sub>3</sub> liquor.....	3	1.0	92	3.2	6.4	94	3540	15
Retanned with 8% Al <sub>2</sub> O <sub>3</sub> liquor.....	3	1.6	96	4.7	5.2	80	3120	19
Retanned with 8% Al <sub>2</sub> O <sub>3</sub> liquor .....	5	2.0	101	6.5	5.1	57	3890	18
<i>Citrate-Masked liquors</i>								
Bends								
Retanned with 4% Al <sub>2</sub> O <sub>3</sub> liquor .....	3	1.1	93	0.3	8.5	104	3310	18
Retanned with 8% Al <sub>2</sub> O <sub>3</sub> liquor.....	3	1.6	96	11.6	7.0	86	3380	20
Retanned with 8% Al <sub>2</sub> O <sub>3</sub> liquor.....	5	1.9	101	6.5	5.1	59	3890	18
<i>Unmasked liquors</i>								
Bellies and shoulders								
Vegetable control.....	—	—	76	—	4.5	151	4470	32
Retanned with 4% Al <sub>2</sub> O <sub>3</sub> liquor.....	3	1.8	98	6.8	6.6	49	4590	28
Retanned with 8% Al <sub>2</sub> O <sub>3</sub> liquor.....	3	2.0	100	6.2	6.0	66	3550	28
Retanned with 8% Al <sub>2</sub> O <sub>3</sub> liquor.....	5	2.2	103	13.0	4.1	31	3040	18
<i>Citrate-Masked liquors</i>								
Bellies and shoulders								
Retanned with 4% Al <sub>2</sub> O <sub>3</sub> liquor.....	3	1.8	94	Loss	11.7	59	2980	25
Retanned with 8% Al <sub>2</sub> O <sub>3</sub> liquor.....	3	1.8	97	9.2	8.3	78	3200	23
Retanned with 8% Al <sub>2</sub> O <sub>3</sub> liquor.....	5	2.3	100	7.7	3.9	59	4050	30

\* At load of 50 kgs. per cm.

TABLE III

## Vegetable Tanned Leathers Retanned with Acetate-Masked Alum Liquors

Position of Sample	Tannage	Al <sub>2</sub> O <sub>3</sub> Content	Shrinkage Temp.	Gain in Weight	Loss in Area	Water Absorbed in 2 hours	Tensile Strength	Elongation*
		Per Cent	°C.	Per Cent	Per Cent	mg./sq. cm.	lbs./sq. in.	Per Cent
<i>Leathers Vegetable-Tanned and Alum-Retanned in the Laboratory</i>								
Bend	Vegetable control	—	81	—	—	214	3080	26
Bend	Alum retanned	3.10	116	12.7	3.0	115	3050	24
Shoulder	Vegetable control	—	81	—	—	160	1900	29
Shoulder	Alum retanned	3.93	108	16.1	2.5	100	2180	27
Belly	Vegetable control	—	80	—	—	142	2810	27
Belly	Alum retanned	3.89	117	15.4	2.7	37	2850	21
<i>Leather Commercially Vegetable-Tanned; Alum Retanned in the Laboratory</i>								
Bend	Vegetable control	—	81	—	—	165	3480	25
Bend	Alum retanned	3.24	109	13.2	3.7	80	3260	23
Shoulder	Vegetable control	—	81	—	—	158	3520	24
Shoulder	Alum retanned	4.59	114	17.7	2.9	115	3400	23
Belly	Vegetable control	—	80	—	—	149	3030	25
Belly	Alum retanned	4.20	115	14.3	2.3	52	2740	21

\* At 75 kgs. per cm.



turned intermittently for a total time of about 3 hours a day. After tannage the leather was washed, oiled and dried. The data obtained in this test are shown in Table III.

By the use of acetate-masked liquor an  $\text{Al}_2\text{O}_3$  content greater than 3 per cent was obtained. In every case the shrinkage temperatures were considerably higher than  $100^\circ \text{C}$ . On retannage, there was some gain in weight, a slight loss in area, a decided decrease in the water absorption capacity, and a slight decrease in the amount of elongation. The tensile strength was only slightly affected.

Samples of these leathers and of the leathers in the first test were split into 3 equal layers—grain, inner and flesh—and analyses were made to determine the  $\text{Al}_2\text{O}_3$  content. In the first test the average  $\text{Al}_2\text{O}_3$  content of the grain and flesh layers was 3.3 per cent, and that of the inner layer was 1.3 per cent. In the second test the average  $\text{Al}_2\text{O}_3$  content of the grain and flesh layers was 4.3 per cent, and the average of the inner layer was 2.6 per cent. In the first test, the  $\text{Al}_2\text{O}_3$  in the inner layer was 40 per cent of that in the outer layers; in the second test it was 60 per cent. A rough qualitative test could be made of the degree of penetration by the boiling test. A poor penetration of  $\text{Al}_2\text{O}_3$  into the interior is indicated by blackening and shrinkage of the fibers in this portion of the leather.

These leathers have been cut into insoles preparatory to an actual wear test, each alum retanned leather being matched with a comparable vegetable control leather. It is believed that since these leathers have a greater  $\text{Al}_2\text{O}_3$  content than the leathers previously tested, they will be superior in wearing qualities. This can be proved only by an actual wear test.

In retanning the insoles used for the Quartermaster tests, there was a loss in area of about 10 per cent. This loss in area did not occur with any of the leathers used in the tests described in this study. If the pieces of leather were rolled or pressed as in commercial practice, however, there was a considerable increase in area of the vegetable tanned pieces and only a slight increase in the alum retanned pieces. The insoles retanned had previously been rolled, increasing their area. This increase in area was lost when they were wet for retanning. This loss could not be regained after retannage because of the greater area stability of the retanned leathers. Thus, in commercial tanning practice, although the retannage does not actually result in a decrease in area, the subsequent rolling will result in a smaller area for the retanned leather than for straight vegetable tanned leather. It is believed, however, that the improved properties due to greater area stability will more than counterbalance the loss in area.

The use of a tanning drum for the retannage has several objections. It ties up a comparatively expensive piece of equipment for several days, and there is some cost for power for turning it. The pounding the leather receives in the drum has a tendency to abrade the grain surface. Experiments have

shown that the use of the drum for retannage is not necessary, the more gentle motion of the rocker vats being sufficient for efficient tannage.

In order to incorporate the desired amount of  $\text{Al}_2\text{O}_3$  into the leathers, the procedure used requires liquors containing about 10 per cent  $\text{Al}_2\text{O}_3$  based on the weight of the leather, thus leaving about half the alum in the spent liquor. To recover this alum for further use, the following method was developed. In the tanning process, the stock alum liquor was added in portions over 2 or 3 days. The sap liquor from the end of the tannage had approximately the same  $\text{Al}_2\text{O}_3$  concentration as the starting liquor and a pH of 4.2 - 4.4. By adjusting the pH to 3.8, this liquor was satisfactory as a starting liquor. The procedure adopted was to take the sap liquor from one lot of leather, adjust the pH to 3.8, and use it for the starting liquor for the next lot. After the normal time for the first period of tannage, one-third of the liquor was discarded to prevent accumulation of impurities. The liquor was then strengthened with the calculated amount of stock liquor and made to volume. The tannage then proceeded as usual, with another addition of stock liquor at the proper time. After complete tannage, the sap liquor was adjusted to pH 3.8 and used for starting the tannage on the next lot of leather. This procedure was repeated 5 times, with no evidence of accumulation of impurities, of any decrease in the fixed  $\text{Al}_2\text{O}_3$ , or of other undesirable effects.

The following tanning procedure has been adopted. The stock alum solution may be made up as follows: (1) Prepare an aluminum sulfate-sodium acetate solution by dissolving 50 pounds of aluminum sulphate  $\text{Al}_2(\text{SO}_4)_3 \cdot 18\text{H}_2\text{O}$  and 10 pounds of sodium acetate  $\text{NaC}_2\text{H}_3\text{O}_2 \cdot 3\text{H}_2\text{O}$  in 24 gallons of boiling water; (2) dissolve 5 pounds 6 ounces of anhydrous sodium carbonate,  $\text{Na}_2\text{CO}_3$ , in 3 gallons of boiling water; (3) add the sodium carbonate solution to the alum-sodium acetate solution slowly with vigorous stirring. Cool and make up to 30 gallons with water. This should give a stock alum solution containing the equivalent of approximately 3 per cent  $\text{Al}_2\text{O}_3$  with a pH of approximately 3.8. It contains 1 mole of sodium acetate per mole of  $\text{Al}_2\text{O}_3$ . Stronger solutions may be made by increasing the amount of the constituents in proportion to the water, keeping the relative proportions of the constituents constant.

For the tanning operation, use 10 per cent  $\text{Al}_2\text{O}_3$ , based on the weight of the air-dry vegetable tanned leather. One-third of this may be obtained from the sap liquor of the previous run and two-thirds from the stock solution. Adjust the sap liquor to pH 3.7 - 3.8 and tan the leather in rocker vats, paddles or drums for 4 hours. Discard one-third of the used tanning liquor. Add the second third of the total stock liquor required, adjust the volume and tan for 1 day. Add the remaining one-third of the stock solution required and tan for 1 to 3 days additional, depending on the thickness and firmness of the leather. During this time, raise the pH to 4.8 by gradual additions of sodium bicarbonate or borax. Remove the leather, wash and finish. Adjust the sap liquor to pH 3.8, and use it for a new lot of leather.

## SUMMARY AND CONCLUSIONS

The alum retannage of vegetable leather changes the properties of the leather in some important respects. It increases greatly the resistance to moist heat and to molds, and it decreases the water absorption and the elongation. It has only slight effects on other properties, such as tensile strength, resistance to tear, porosity, and permeability to water vapor.

A previously used procedure for alum retanning of light weight vegetable tanned leather has been modified by use of suitable masking agents, such as sodium acetate, and by other means to adapt it for retanning heavy vegetable leathers of the insole type. This modified process has given more uniform penetration and higher fixation of  $\text{Al}_2\text{O}_3$ . The retanned belly leathers have  $\text{Al}_2\text{O}_3$  contents ranging from 3.9 to 4.2 per cent, and shrinkage temperatures ranging from 115° to 117° C. These leathers may be boiled in water for 3 minutes without injury or change in area.

The retannage can be effectively done in rocker vats as well as in tanning drums and alum tanning liquors can be conserved by reuse of adjusted sap liquor as a first-stage tanning liquor.

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## DISCUSSION

R. B. HOBBS: The Eastern Regional Laboratory, I understand, does not participate financially in the support from the Quartermaster General's Research Program, but they do cooperate so that those who take part are justified in considering themselves collaborators. That gives us an excuse to use this paper as an illustration of two of the points that Dr. Kennedy made this morning on aspects of the program. First: the search for materials which would replace those that are in somewhat less copious supply and which would relieve to some extent our dependence on foreign sources for such tanning materials as chrome and the scarcer vegetable tannins. The strategic significance of this paper in that connection is obvious, I think. At the same time, it is a development in the connection that Dr. Kennedy mentioned, of

making available leather for military use, with a significantly different standard of quality than what we have been accustomed to prepare for civilian use. I understand that plans are being made to put leathers of this type—alum retannage, tanned commercially—into service tests. If, as may be anticipated, the results of these demonstrate conclusively the complete practical significance of this technique, we are faced with this problem: That, as an ordinary practice, insole leathers come substantially from the same production line as outsoles, welting, strap leathers, and so on. Tanners will be understandably reluctant to introduce any further changes in their production line; and that brings us to the question of whether alum retannage will be effective for these other types of vegetable leathers. For that reason I would like to ask Mr. Beebe whether any work is contemplated on the use of alum retannage for outsoles, for straps or welting leathers?

C. W. BEEBE: In the tanning tests, we tanned the whole side which gives us the bends as well as the bellies, and the bends are almost as well retanned as the belly and shoulder portions. We have not contemplated any particular use for outsole leathers, although they might have some advantages. We will probably look into that later. Of course, it is always possible that the sides will be tanned to a suitable stage of tannage, then the bellies could be cropped from the sides without too much trouble and given an alum retannage and the bends would go through the usual process. I should think it could be accomplished without too much disruption of the tannage process. We are trying other methods of retannage on these bellies that would be more in line with regular tanning processes to save time and cost. For example, it has been suggested that we try to dry dip these bellies in the alum solutions and then, by further neutralization, we might have as much success with that as with the present process that I have recommended here.

HOBBS: Such a dry dip process might also have the effect of avoiding the loss of considerable tanning material. I think it is rather gratifying that you are devoting adequate attention to the commercial aspects of this technique. A related question is this: If this process is to be used for the replacement of chrome in times of national emergency, it would be interesting to know whether alum retanned leathers would be suitable for shoe upper leathers. I wonder if that also would be considered?

BEEBE: I think that might be our next step, in place of sole leather, to try alum retannage for upper leather, too. Of course, there are problems there in dyeing the alum retanned leather and other problems of that nature.

H. B. CHANNON: I think it was in the pretannage with calgon that as the fixation of the aluminum oxide decreased and the curling point decreased, that the tensile strength increased. Is there any explanation for that?

BEEBE: You mean a shrink test.

CHANNON: Is there any explanation for the increase in tensile strength?

BEEBE: Those were on samples of a large number of tests and upon looking over those figures I find there is so much variation in the figures I do not consider that the difference in tensile strength is significant in any way.

CHANNON: Wasn't there a factor of time in that tannage?

BEEBE: A factor of time—in other words, there is a shortening of the time of the vegetable tannage after calgon pretannage. Is that what you mean?

CHANNON: To me it was rather significant that the tensile strength increased. I do not think that ought to be overlooked.

BEEBE: As I say, these were an average of a large number of tests and, apparently there was a slight increase in tensile strength but it was not really significant. We could not consider it significant because there was so much variation in the tensile strength due to other factors.

HOBBS: Looking over these figures again, I notice that we have perhaps a maximum difference in tensile strength between leathers with two alum contents of something in the neighborhood of a thousand pounds, and most of them less. Ordinarily, for a group of specimens of this size, we expect that the difference should be at least twelve or fifteen hundred pounds to even begin to think about significance.

H. P. MORTON: Have you had experience in alum treatment of India tanned hides, kips or buffaloes? And do you think it could be applied particularly for making lining leather?

BEEBE: I should think it could. I have had no experience but I do not see why it could not be applied.

MORTON: Would you also recommend the sides be stripped before alum treatment is started?

BEEBE: They do not have to be stripped drastically. A slight washing is sufficient.